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Introduction

The status of biology in Kant's philosophy of science is often deemed to be highly problematic. In the *Metaphysische Anfangsgründe der Naturwissenschaft* (1786), Kant specifies several conditions that a proper natural science must satisfy. *Prima facie*, only Newtonian physics satisfies these conditions. Hence, it is not uncommon to think that Kant dismisses all other doctrines of nature as unscientific. This also holds for biology, which is taken to be unscientific because it does not satisfy the conditions of proper (Newtonian) science. In line with this view, organisms, constituting the object of biological investigation, have been described as capital anomalies that do not fit into Kant's system of science.¹ There is apparently no way of "reconciling biology *at all* with Kant's prescriptions for science".² There thus seems to be a profound discrepancy between Kant's views on biology and his views regarding proper natural science. This raises the question how these two sets of views are precisely related.

The main aim of this dissertation is to analyze Kant's philosophical views regarding biology from the point of view of his conception of proper natural science. I aim to show how Kant's conception of proper natural science and method, as articulated most explicitly in his *Metaphysische Anfangsgründe* of 1786, influences his conception of biological science and methodology as articulated in the *Kritik der Urteilskraft* of 1790 and in the *Opus postumum* of 1796–1803. In doing so, I relate two strands of Kant's philosophy of science

¹ Zammito 2006, 763. Cf. Guyer 2001.

² Zammito 2003, 102.

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that have separately received a lot of attention but are seldom treated in conjunction. My main thesis is that Kant's conception of biological science and methodology is continuous with and profoundly influenced by his views on proper natural science. Kant adopts a classical model of scientific rationality and we can only properly understand his views relating to biology on the basis of this model.

The present study contains three main sub-arguments. Given the scope of the study, it is useful to briefly present them:

First (i), I explicate Kant's conception of proper natural science. Kant is shown to adopt a traditional ideal of scientific explanation. Scientific explanation consists in providing an explanative demonstration, i.e., a demonstration showing *why* things are such and such. This ideal of explanation leads Kant to privilege so-called mechanical explanations. Insofar biology contains proper scientific explanations, they are mechanical explanations. Teleology is not explanatory in biology. However, teleology is a necessary presupposition of biology insofar it allows us to determine and delimit the object or domain of biology.

Second (ii), Kant construed physics as a science that should constitute a systematic unity. Biology is a part of physics. In particular, it is a part of physics traditionally called *physica specialis*, which was conceptualized as being grounded in the universal doctrine of nature (*physica generalis*). For Kant physics does not reduce to mathematical (Newtonian) physics. As a part of *physica specialis*, biology must ultimately be grounded in *physica generalis*. As such, biological phenomena must ultimately be explicable in terms of more fundamental physical laws or forces. Kant did not and could not specify how biology is grounded in other more fundamental sciences. However, the idea that biology should be grounded in more fundamental physical sciences is a persistent methodological ideal.

Third (iii), Kant construes both the claim that one should comprehend organisms in teleological terms and the claim that one should explain organisms mechanically as regulative methodological maxims. These maxims should not be conflated with ontological theses. Kant criticizes several biological theories of his contemporaries insofar as he takes them to go beyond the domain of science into the domain of metaphysics.

The result of my analysis is that although biology does not satisfy all of Kant's prescriptions for proper natural science, Kant did articulate a method for biology that in many ways conforms to these prescriptions. By the standards of the *Metaphysische Anfangsgründe*, biology is not a proper natural science simply because it is not a mathematical science. However, by em-

phasizing that teleology determines the object or domain of biology, Kant specified the conditions under which biology can be taken to have a determinate object of investigation. By construing mechanical explanations as ideal forms of explanation, and allowing for mechanical explanations in biology, Kant allows for the possibility of objective and explanative demonstrations in biology. Finally, by treating biology as a part of physics grounded in more fundamental sciences, Kant's treatment of biology conforms to the ideal that physics should constitute a systematic unity. Kant's views on proper natural science thus strongly determine his views of biological methodology and there is no fundamental discrepancy between these two sets of views.

Kant's philosophy of natural science has, as is the case for Kant's philosophy in general, received enormous scholarly attention. The literature on the topic is vast and sometimes hard to survey. There also exist numerous different strands of interpretation concerning Kant's philosophy of natural science (each with its own history), which, given the amount of literature on this topic, are not always easily identifiable. Roughly, we may say that a dominant strand of interpretation has focused on Kant's philosophy of what we may call the physical sciences. Within this strand, in which the *Metaphysische Anfangsgründe* is taken as one of the main texts of interest, Kant's philosophical foundation of dynamics, mechanics, his theory of matter, his views on the methodology and epistemology of physics, and (more recently) his views on chemistry, have received much attention.³ A different strand of interpretation has focused more on Kant's inquiries in the life and human sciences. In the last decades, interest in Kant's views on such sciences as psychology, anthropology and history has steadily increased.⁴ This is also true of Kant's philosophy of

³ Erich Adickes provided one of the first comprehensive historical analyses of Kant's philosophy of nature and science (spanning Kant's pre-critical writings up until the *Opus postumum*). Cf. Adickes 1924–25. Influential systematic treatments of Kant's philosophy of natural science have been given by Plaaß 1965; Buchdahl 1969; Gloy 1976; Hoppe 1969; Brittan 1978; Cramer 1985; Butts 1984; Friedman 1992a; Falkenburg 2000. Carrier 1990, 2001a, and Friedman 1992a provide analyses of Kant's views on chemistry. More recently, Konstantin Pollok has provided a formidable critical commentary of Kant's *Metaphysische Anfangsgründe*, which includes a 13 page biography of secondary literature relating to the latter work. Cf. Pollok 2001.

⁴ Kitcher 1990 provides an influential account of Kant's views on psychology. Eric Watkins (ed.) 2001, provides a fairly recent anthology containing essays on psychology, anthropology, history and biology. Sturm 2001 treats Kant's views on psychology, whereas Makkreel 2001 treats of psychology, anthropology and history. On history, see also Kleingeld 1999.

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biology, a topic which has been intensively researched in the past decades.⁵ The present study aims to relate these two lines of interpretation by showing how Kant's conception of proper natural science determines his conception of biological methodology.

The usefulness of this approach can be shown by positioning the present work with respect to two dominant strands of interpretation concerning Kant's philosophy of biology. One strand of interpretation, which can be traced to Clark Zumbach's *The Transcendent Science* (1984), stresses that Kant strongly affirms the autonomy of biology. Biology is presented as an autonomous science, with its own particular standards and methodology, which is irreducible to physics. Thus, Zumbach argues that biology has its own particular 'mode of explanation', which cannot be introduced by the mechanical (physical) point of view.⁶ This mode of explanation is made possible by a teleological point of view. In effect, teleology is assigned some kind of explanatory function in natural science. According to Zumbach, teleology is a permanent and irreducible conceptual feature of biology, which implies that biology is irreducible to physics. Kant is thus shown to be a methodological or explanatory anti-reductionist, although he is *not* an ontological anti-reductionist.⁷

According to Zumbach, Kant distinguishes between two types of explanation. On the one hand, to "explain the occurrence of a phenomenon is to give a causal account of it".⁸ On the other hand, he notes that "we recognize a sense of "explanation" where "to explain" is "to bring understanding".⁹ This latter type of explanation is brought about by teleology, which allows us to *unify* a certain range of phenomena or facts. To cite an example from Kant, if we view the construction of a bird as having the *purpose* of enabling flight, we comprehend the particular unity of this construction, e.g., of the hollowing in its bones, the position of its wings, the position of the tail, etc.¹⁰ In this manner, Zumbach introduces a notion of scientific explanation strongly related to unification. Recently, Hannah Ginsborg and Marcel Quarfood have adopted a similar line of interpretation, arguing that teleology enables us "to regard

⁵ The historian of science Timothy Lenoir has extensively analyzed Kant's philosophy of biology in light of eighteenth- and nineteenth-century biology. Cf. Lenoir 1980, 1981, 1989. Lenoir's work has given rise to much debate and has spawned historical and systematic research on Kant's philosophy of biology. Influential discussions include: Löw 1980; Zumbach 1984; McLaughlin 1990; Zammito 1992, 2003, 2006; Larson 1994; Richards 2000, 2002; Ginsborg 2001, 2004; Guyer 2001, 2005; Sloan 2002, 2006.

⁶ Zumbach 1984, 92.

⁷ *Ibid.*, 87–92.

⁸ *Ibid.*, 110n.

⁹ *Ibid.*, 123.

¹⁰ AA 5: 360.

biological regularities as lawlike or necessary”¹¹, and that teleology “serves as a substitute” for mechanical laws of nature in cases where “we find no other way to unify the regularities that cry out for explanation”.¹²

A second line of interpretation concerning Kant’s philosophy of biology, of which John Zammito is one of the most influential spokesmen¹³, adopts a more skeptical stance towards the status of biology. As said, Zammito argues that Kant denies that biology can ever be reconciled with his prescriptions for science. Organisms are anomalies that threaten the ideal of science as constituting a systematic unity. The mechanical inexplicability of organisms implies that organisms cannot be properly explained. Finally, there is a fundamental discrepancy between Kant’s views on biology and that of his contemporary life scientists. As Zammito forcefully puts it: only “by misunderstanding Kant did biology as a special science emerge at the close of the eighteenth century”.¹⁴ Or as Robert Richards argues, the reception of Kant’s third *Critique* by late eighteenth-century biologist and conversely Kant’s reception of late eighteenth-century biological theories is a case of a ‘historical misunderstanding’.¹⁵

The first line of interpretation has greatly increased our understanding of Kant’s views on biology. It correctly stresses that, according to Kant, we necessarily conceptualize organisms, constituting the object of biology, in teleological terms. In the present study, I will further develop this interpretation from a historical perspective, arguing that teleology determines the object or domain of biology. It is only *because* we conceptualize certain objects of nature teleologically that biology has a distinct object of scientific investigation. This view, I argue, conforms to a conception of teleology implicit in eighteenth-century biology, articulated most explicitly by Johann Friedrich Blumenbach, according to which teleology is taken to be operative in determining the domain of biology (Chapter 3). Moreover, it is not only contained in Kant’s third *Critique*, but also in the *Opus postumum*, a text hardly ever analyzed in relation to Kant’s views on biology (Chapter 5).

In contrast to the first line of interpretation, however, I argue that Kant denies teleology any explanatory function. The reason is simply that he adopts a very strict conception of proper explanation in natural science. This becomes clear if we, in contrast to the mentioned authors, relate Kant’s views on biology to his views on proper natural science. In Chapter 1, I argue that according to

¹¹ Ginsborg 2001, 248.

¹² Quarfood 2006, 738.

¹³ Zammito 1992, 2003, 2006.

¹⁴ Zammito 2006, 765.

¹⁵ Richards 2000. Cf. Richards 2002, 229.

Kant fundamental judgments of a proper science must *objectively ground* non-fundamental judgments. The idea of objective grounding is related to Kant's views on proper explanation. In providing a proof of a non-fundamental judgment, we must provide an explanative demonstration of this judgment, i.e., a deductive demonstration specifying the objective ground(s) for *why* something is the case. In Chapters 2 and 3, I show that this conception of scientific explanation informs Kant's views on mechanical explanation, as articulated in the third *Critique*. Proper explanations in biology are mechanical explanations and teleology is denied any explanatory function.¹⁶ As such, Kant's views on proper natural science and scientific explanation are shown to strongly influence his conception of biological methodology. Importantly, the ideal of mechanical explanation is a methodological ideal that does not have any ontological implications. That we should explain organisms mechanically does not imply, for example, the metaphysical doctrine of materialism. Hence, contrary to what Zumbach suggests, Kant opposes ontological reductionism.

The second line of interpretation has also greatly increased our understanding of Kant's philosophy of biology. It has especially highlighted the sometimes problematic relationship between Kant's philosophy and eighteenth-century biology. However, the negative assessment of Kant's views regarding the scientific status of biology expounded within this strand of interpretation is (I maintain) not based on a thorough analysis of Kant's views regarding proper natural science. In Chapters 1 and 2, I show that Kant's views on proper scientific explanation inform his views on mechanical explanation. Moreover, organisms allow (in certain respects) of mechanical explanation. As such, Kant's views regarding proper natural science and proper explanation determine his conception of biological methodology. There is no fundamental discrepancy between these two sets of views.

In line with his unitary conception of proper scientific methodology and explanation, Kant treats biology as a part of physics grounded in more fundamental physical sciences. Biological phenomena, though necessarily viewed from a teleological perspective, must be explained in terms of more fundamental physical (or physico-chemical) laws and forces (Chapters 4 and 5).

¹⁶ Note that Zumbach does seem to interpret teleology as explanatory in the sense that I have specified. Thus, he writes that "purposiveness arises where there is a causal relation in which the idea of the effect may *prima facie* be cited as an explanation for why the cause of that relation occurred". Zumbach 1984, 9. Here, the 'idea of the effect' is a *purpose*. More recently, Kreines has argued that according to Kant a teleological judgment "*M* is for *E*" implies that *M*'s benefit to *E* explains why *M* exists or occurs (namely for the sake of *E*). Cf. Kreines 2005, 272–273. In my view, Kant never takes teleology to explain *why* something is the case (Chapter 2 and 3).

As such, although Kant never fully explicated the manner in which biology is grounded in other sciences, it is not the case that biology is an anomaly within Kant's theory of science threatening the ideal of science as a systematic unity. Finally, an analysis of Kant's *Opus postumum* (Chapter 5) shows that Kant, up to the end of his life, was engaged in providing a philosophical interpretation of late eighteenth-century biological theories. Although there exist, as Richards and Zammito emphasize, great differences between Kant's views and those of his contemporary biologists, it is not the case that Kant's reception of these theories is a case of a historical misunderstanding. Rather, Kant tried to integrate fundamental biological concepts in his philosophy on the basis of doctrines developed in the third *Critique*.

Apart from analyzing Kant's conception of biological method on the basis of his views on proper natural science, the present study adds to existing interpretations by taking into account the *Opus postumum*. In discussions on Kant's views on biology, the latter work is hardly ever taken into account. In studies of the *Opus postumum*, Kant's reflections on organic nature are often treated only marginally and not in relation to his views on biology or 18th century biological theories.¹⁷ In my view, our understanding of Kant's views on biology can be increased by taking into account the *Opus postumum* (Chapters 4 and 5). In this projected work, we find clear expression of the idea that teleology determines the object and domain of biology, that proper explanations in biology are mechanical explanations, and that biology is a part of physics grounded in more fundamental physical sciences. In addition, the *Opus postumum* shows that Kant tried to provide a philosophical interpretation of late eighteenth-century biological theories. Hence, the relationship between Kant's views on biology and late eighteenth-century biological theories becomes clearer by taking this work into account, even if, as I argue, Kant's position in the *Opus postumum* is substantially the same as his position adopted in the *Kritik der Urteilskraft*.

¹⁷ Erich Adickes 1920, providing the first comprehensive historical analysis of the *Opus postumum*, does treat of Kant's reflections concerning organic nature, but not in relation to his views on biology and eighteenth-century biological theories. The same is true of Tuschling 1968, Mathieu 1989 and Hoppe 1969. Eckart Förster 2000, one of the most influential interpreters of the *Opus postumum*, typically treats of the reflections on organic nature contained in Kant's last projected work as mere preliminaries to the *Selbstsetzungslehre*. Michael Friedman 1992a, in his discussion of the *Opus postumum*, entirely abstracts from any discussion relating to biology. The same is true of Edwards 2000 and Emundts 2004. Noteworthy exceptions to this dominant trend of interpretation include Heimsoeth 1940, Löw 1980 and to a lesser extent Guyer 2001.

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The method employed in this study is a combination of historical reconstruction and history of ideas. The main focus of inquiry is Kant's conception of proper natural science and biology as articulated in the critical corpus and the *Opus postumum*. With respect to the critical period, the *Metaphysische Anfangsgründe* (1786) and the *Kritik der Urteilskraft* (1790) are key texts of analysis. However, I confront these texts from a general perspective. In explicating Kant's views on proper natural science and biology in the critical period, I employ pre-critical works, various early and late essays of Kant relating to the topic of biology, the *Jäsche Logik* and notes from Kant's lectures on logic, metaphysics and physics. The inclusion of works predating the first *Critique* is motivated by the fact that Kant was concerned with analyzing natural science and topics relating to biology throughout the whole of his philosophical career.¹⁸ A study of Kant's early views on natural science and biology increases our understanding of his later views on these topics. It is for this purpose that I employ the pre-critical writings and early essays relating to biology. The inclusion of the *Jäsche Logik* and lecture notes is motivated by the fact that these sources provide invaluable insight into Kant's views on scientific methodology. In dealing with these sources, I am focused on continuities in Kant's thought. In this manner I identify core Kantian views regarding proper natural science and biology. A detailed historical analysis of changes in Kant's philosophy of science and biology lies beyond the scope of this work.

The focus on continuity is also apparent in the strong *ideengeschichtlich* character of the present study. In my view, Kant's views on proper natural science, scientific method and biological method conform to traditional ideals of scientific rationality that were widespread in the modern period. Hence, we can increase our understanding of Kant's views on natural science and biology by taking into account the views of his philosophical and scientific predecessors. The *ideengeschichtlich* character of this study is reflected in Chapter 1, in which I employ the Classical Model of Science as developed by de Jong & Betti in order to analyze Kant's conception of proper natural science.¹⁹ In addition, Kant's views on objective grounding and on the role of mathematics in natural science are analyzed in relation to the works of Christian Wolff and Isaac Newton. In Chapter 2, Kant's views on mechanical explanation are analyzed in relation to Christian Wolff's views on scientific explanation. Chapter 3 analyzes Kant's views on teleology on the basis of the views of

¹⁸ For an analysis of Kant's pre-critical views on natural science, see for example Friedman 1992a, 1–52. See also Falkenburg 2000. The importance of biological topics in Kant's early writings has been stressed by Zammito 1992. Cf. Sloan 2002, 2006; Ferrini 2000.

¹⁹ De Jong & Betti 2010.

Alexander Gottlieb Baumgarten's conception of teleology, and his views on biology on the basis of ideas of the biologist Johann Friedrich Blumenbach. In Chapter 4, Kant's conception of physics, as expounded in his critical works and in the *Opus postumum*, is studied in relation to the construal of physics given in eighteenth-century textbooks. Finally, Chapter 5 discusses Kant's reflections concerning biology in the *Opus postumum* on the basis of his early essays concerning biological issues, the third *Critique* and then contemporary biological theories and metaphysical interpretations thereof.

The *ideengeschichtlich* method provides a novel perspective on Kant's philosophy of natural science and biology. In particular, it provides a novel perspective on Kant's views on grounding in natural science, which in turn allows us to better understand Kant's views on the role of mathematics and metaphysics in natural science. Whereas the notion of grounding is typically comprehended in epistemic terms,²⁰ I relate this notion, also taking into account the philosophy of Christian Wolff, to the idea of objective scientific explanation (Chapter 1). In addition, Kant's philosophy of biology has to my knowledge never been related to Christian Wolff's views on scientific explanation and biological methodology. There are some noteworthy similarities and differences between the views of Wolff and Kant on the methodology of natural science and biology. An investigation of these continuities and differences will increase our understanding of Kant's views on biology, even those espoused in the late third *Critique* (Chapter 2). The same is true of Kant's views on teleology, which can be profitably understood by taking into account the views on teleology by Alexander Gottlieb Baumgarten (Chapter 3). Finally, Kant's views on biology espoused in the *Opus postumum* have rarely been investigated in relation to then contemporary biological theories and metaphysical interpretations thereof. The present study aims to do just that (Chapters 4 and 5).

Before presenting an overview of the structure and contents of this dissertation, two methodological remarks are in order. First, it must be emphasized that the present study is concerned with providing an analysis of Kant's conception of proper *natural* science. In analyzing this conception, I also treat conditions that according to Kant any science must satisfy. However, these conditions are always analyzed in relation to Kant's views on natural science. The present study does *not* aim to investigate Kant's views on how, e.g., mathematics or transcendental philosophy can constitute proper sciences.

Second, it must be emphasized that the use of the term 'biology' is slightly

²⁰ Cf. Friedman 1992b.

anachronistic. It is common to locate the origin of the term biology, designating a special science of life, in 1802 when Gottfried Reinhold Treviranus published the first volumes of his *Biologie, oder Philosophie der lebenden Natur*. In the same year, Jean-Baptiste de Lamarck employed the term biology in a similar fashion.²¹ Thus, the term biology became accepted right before Kant's death in 1804. To my knowledge Kant never employed the term 'biology'. However, in contemporary discussions of Kant it is quite common to employ this term as referring to various disciplines dealing with organic nature, e.g., zoology and botany (two realms of natural history), physiology, embryology, (comparative) anatomy.²² In the present study I follow this usage of the term biology.

Given the scope of the present study, it is useful to provide a detailed account of the structure and contents of this dissertation. This account provides the reader with a guiding thread in order to comprehend the argumentative structure of the dissertation.

In **Chapter 1**, I analyze Kant's conception of proper natural science. I identify three core conditions that Kant thinks a proper natural science must satisfy: (i) systematicity, (ii) objective grounding and (iii) apodictic certainty. These conditions are analyzed in relation to the Classical Model of Science.

Kant's notion of systematicity (i) is treated in relation to his views on the ordering of concepts. A system of concepts is a homogeneous ordering with specified bounds, in which concepts are ordered through definitions and through the specification of their extension by means of logical division. Kant's idea of (objective) grounding (ii) is discussed in relation to his views on the ordering of concepts *and* his views on the ordering of judgments. I argue that both concepts and judgments of a science satisfy different kinds of grounding-relations. With respect to judgments, I take Kant to hold that the judgments of a proper science must be grounded in more fundamental judgments. This relation of grounding is stronger than that of logical derivability: more fundamental judgments in science must *objectively ground* less fundamental judgments. This entails that in providing a scientific proof of a judgment α , we must provide an *explanative demonstration* of α . Kant thus adopts a traditional Aristotelian ideal of scientific explanation, i.e., the idea

²¹ Cf. Hodge 1971, 323–352; Theunissen & Visser 1996; Richards 2000, 12. Note however that earlier uses of the term have been described by historians of science. McLaughlin 2002, mentions Karl Friedrich Burdach's use of the term in 1800, Theodor Georg August Roose's use of the term in 1797, and even Michael Christoph Hanov's use of the term in 1766.

²² Cf. Zumbach 1984, Richards 2000.

that in science we should provide a demonstrative syllogism or a *demonstratio propter quid*. This is a demonstration providing the reason *why* things are such and such. Finally, the notion of apodictic certainty (iii) primarily captures an epistemic requirement that the judgments of a science must satisfy. According to Kant, the judgments of a proper science must be apodictically certain, i.e., we must be justified in asserting their necessary truth. This condition implies that the judgments of a science must allow of proof from *a priori* principles.

Conditions (ii)–(iii) allow us to understand why Kant argues that any proper natural science must contain mathematics and be based on metaphysics. I argue that Kant takes mathematics to be necessary for natural science because it ensures the apodictic certainty of judgments of natural science *and* because it aids us in providing proper scientific explanations (demonstrations *propter quid*). For the very same reasons, Kant takes metaphysics to be necessary for natural science. Hence, proper natural science does not merely require mathematics and metaphysics in virtue of the epistemic function the latter fulfill in justifying scientific cognition. Mathematics and metaphysics are also necessary because they allow us to provide objective scientific demonstrations.

In **Chapter 2**, some of Kant's views on proper natural science are applied to his views on the possibility of scientific cognition of organisms. In the *Kritik der Urteilskraft*, Kant famously argues that organisms defy mechanical explanation. The main aims of the second chapter are to specify how Kant understands the notion of mechanical explanation and why mechanical explanation is construed as an *ideal* of scientific explanation. I argue that mechanical explanations are construed as proper explanations because they are understood as providing *objective* scientific explanations (demonstrations *propter quid*).

Kant roughly construes a mechanical explanation as an explanation of the features of a whole in terms of its parts. In order to understand what this entails, I analyze Christian Wolff's views on scientific explanation. I argue that part/whole conceptualizations figuring in Wolff's logic and metaphysics influence his view on scientific explanation in natural science. In logic, definitions are construed as explanations of wholes in terms of their parts and mode of composition of these parts. In his metaphysics, Wolff argues that cognition of the parts of a thing and their mode of composition provides cognition of the *essence* of a thing, which contains the ground (reason *why*) of its attributes. In this manner, the ideal of objective scientific explanation is associated with explanations of wholes in terms of their parts: through cognition of the parts of a thing and their mode of composition we can explain *why* a thing has certain attributes. This idea of explanation is extended into the domain of

natural science. In natural science, we explain features of corporeal bodies in terms of: (a) their parts, (b) the mode of composition of these parts and (c) forces acting upon the parts. Explanations in terms of (a)–(c) are *mechanical explanations*. Wolff attempts to provide such explanations in the field of biology, arguing that we can only specify the true *ground* of the growth, nutrition and propagation of plants and animals on the basis of cognition of their parts and mode of composition.

Kant is shown to adopt a rather similar view on mechanical explanation. As in the case of Wolff, this view is based on part/whole conceptualizations employed within logic. As such, the notion of mechanical explanation is based on a philosophical interpretation of what constitutes proper explanation and proper method in science. This allows us to understand why Kant treats the prescription that one should always explain objects of nature mechanically as a *regulative maxim*: we are dealing with a prescription concerning proper method in natural science that does not have ontological implications. Finally, I argue that Kant's claim that organisms defy mechanical explanation concerns one particular feature: the order and unity of the parts of organisms. We cannot mechanically explain *why* the parts of organisms exhibit a harmonious unity.

Chapter 3 contains an analysis of Kant's views on the role of teleology in biology. The main thesis of this chapter is that Kant does not assign any explanatory role to teleology. However, teleology is assigned a role in determining the object or domain of biology.

In the first part of Chapter 3, I investigate Kant's teleology from a historical perspective. I analyze Alexander Gottlieb Baumgarten's construal of the concept 'purpose' in his *Metaphysica*. Baumgarten treats of the concept purpose while discussing various types of *causes*. He discusses the *genus* (i) cause, and the *species* (ii) efficient cause, (iii) usefulness or utility and (iv) purpose. Baumgarten construes the connection between efficient causes and effects (the *nexus effectivus*) to be an objective relation obtaining between existing objects. This relation is objective not only in the sense that it obtains between existing objects, but also in the sense that it is a relation taken to obtain between objects irrespective of the manner in which these objects are represented or conceptualized by some cognitive (volitional and intellectual) subject. The latter is not true of the connection between means and purposes (the *nexus finalis*). An object is a purpose only relative to some cognitive subject that *represents* this object as good and tries to obtain this good by *employing* certain means. Purposes and means only exist relative to some cognitive subject capable of acting in accordance with representations.

Kant's conception of 'purpose' is shown to be similar to that of Baum-

garten. This partly explains why Kant does not assign any explanatory role to teleology in natural science or biology. Proper explanations in natural science are objective and explanative demonstrations representing the order of nature. However, the appeal to the *nexus finalis* in natural science leads us *beyond* the order of nature. The *nexus finalis* is a connection of *ideal* causes. Purposes are subjectively ascribed to objects of nature and are not objective grounds in terms of which we can explain *why* something is the case. In biology, proper explanations are mechanical explanations, which are associated with explanations in accordance with the *nexus effectivus*. In contrast to efficient causes, final causes do not specify the objective grounds of processes such as (e.g.) regeneration and do not provide insight into the *working* of such processes.

In the second part of this chapter, I argue that teleology determines the object or domain of biology. By conceptualizing organic bodies as *natural purposes*, we take them to be characterized by properties and relations that we do not ascribe to inorganic bodies. As such, the *method* that we employ in investigating organisms determines how we understand the object of biology.

I first show that according to Kant the *mechanical method* of investigating organic bodies determines how we understand the nature of organisms. The regulative ideal of mechanical explanation, i.e., the methodological claim that one should explain wholes in terms of their parts, leads us to view organisms as wholes consisting of relatively simple parts. This claim does not imply the ontological thesis that organisms exist of simple elements.

Kant's views on how *teleology* determines the object of biology are analyzed by taking into account the manner in which the biologist Johann Friedrich Blumenbach distinguishes organic from inorganic bodies. Organic bodies (plants and animals) are distinguished from inorganic bodies by characterizing the former in terms of (i) reproduction, (ii) nutrition and growth and (iii) a particular structure. (i)–(iii) provide criteria for distinguishing organic from inorganic bodies and are understood in teleological terms. Most importantly, organisms must have a *purposive structure* (iii) that is adapted to performing the functions (i) and (ii). In this manner, teleology is assigned a crucial role in distinguishing organic from inorganic bodies.

Kant is shown to assign a similar role to teleology in natural science. In the *Kritik der Urteilskraft*, he treats reproduction, growth and nutrition, and regeneration as *distinguishing traits* of organisms. These traits are described in teleological terms and teleology can be taken to determine and delimit the object of biological investigation. However, Kant retains committed to the idea that we should *explain* all organic phenomena mechanically. The proper method of biology is taken to consist in the *subordination* of mechanism to

teleology. Through teleology, we determine how we understand and delimit the object of biological investigation. In particular, by conceptualizing organisms teleologically, we comprehend them as having a structure adapted to performing organic functions such as (e.g.) growth and nutrition. Given this teleological characterization of the object of biological investigation, we must, however, try to provide mechanical explanations of such processes as growth and nutrition, i.e., explanations specifying the objective grounds (reasons *why*) of such processes.

Finally, I emphasize that it is in its *regulative use* that teleology determines the object or domain of biology. Both mechanism and teleology constitute regulative methodological maxims that determine how we construe the object of biological investigation. Again, they do not constitute or imply ontological claims.

In Chapter 4, we turn our attention to Kant's *Opus postumum*. The *Opus postumum* is a collection of reflections composed for a work originally entitled "Transition from the Metaphysical Foundations of Natural Science to Physics". The main objective of this chapter is to explain what this *Transition* project entails. This objective is attained by analyzing the meaning of the concept 'physics' in the writings of Kant and in eighteenth-century textbooks on physics. I argue that Kant's *Transition* must be understood as an extension of Kant's *Metaphysische Anfangsgründe* of 1786 and that this project is informed by a traditional view on how to ground physics as a systematic science. Biology is shown to be construed as a part of physics.

In the first part of Chapter 4, I analyze Kant's views on physics as articulated in the critical period. Kant adopts a broad Aristotelian conception of physics as a science of nature incorporating any doctrine of nature, including the study of organisms (biology) and mind (psychology). He also adopts a more restricted conception of physics as a doctrine of *corporeal nature*. The latter doctrine includes mathematical physics, chemistry and topics pertaining to biology, while excluding psychology. Hence, it is problematic to equate Kant's notion of physics with mathematical (Newtonian) physics.

Kant further distinguishes between rational (a priori) and empirical physics. On the basis of an analysis of the *Metaphysische Anfangsgründe*, Kant is shown to be aware of the existence of explanatory gaps between rational and empirical physics. Nevertheless, physics should be a systematic science. As such, the necessity of the *Transition*, constituting a transition from rational to empirical physics in order to establish physics as a system, is already apparent in the *Metaphysische Anfangsgründe*.

In the second part of Chapter 4, I analyze how the concept of physics is employed in some eighteenth-century textbooks on physics. The textbooks

I discuss emphasize that one should try to establish physics as a systematic science. Physics is established as a systematic science by grounding *physica specialis*, the special part of physics containing (e.g.) discussion of fluid and solid bodies, chemical topics, electricity, magnetism, in *physica generalis*, a *universal* doctrine of nature containing (e.g.) discussion of the laws of motion and Newton's theory of universal gravitation. The distinction between *physica generalis* and *physica specialis* was conceptualized as a distinction between a priori and empirical physics. In addition, various topics pertaining to biology were rubricated under *physica specialis*. In eighteenth-century textbooks, we are thus confronted with a broad conception of physics as a systematic science comprising multiple doctrines of nature.

In the third part of Chapter 4, I discuss Kant's *Transition*. The *Transition* has the task of grounding physics as a systematic science. The project of effecting a transition from the metaphysical foundations of natural science to physics corresponds to the traditional project of exhibiting the systematicity of physics by grounding *physica specialis* in *physica generalis*. Note that the *Transition* is not identical to the project of grounding *physica specialis* in *physica generalis*. The project of providing the metaphysical foundations of natural science (the *Metaphysische Anfangsgründe*) led to Kant to strictly distinguish between a pure a priori part of physics (rational physics) and an empirical part, and to take certain topics traditionally discussed within *physica generalis*, e.g., cohesion and the law of gravitation, as pertaining to empirical physics. Nevertheless, a study of the project of grounding *physica specialis* in *physica generalis* shows how philosophers and scientists in the eighteenth century tried to establish physics as a systematic science. Kant's *Transition*, which similarly has the task of establishing physics as a systematic science, can be profitably understood against this background.

Through his *Transition*, Kant hopes to bridge explanatory gaps obtaining between rational physics and empirical physics. These gaps were evident to Kant in his *Metaphysische Anfangsgründe* of 1786. In eighteenth-century textbooks on physics, the existence of gaps between *physica generalis* and *physica specialis* is also clear. Kant's *Transition* is thus an extension of his *Metaphysische Anfangsgründe* of 1786 and is a project similar to a traditional project of grounding the systematicity of physics. Finally, since biological topics were rubricated under *physica specialis*, the *Transition* also incorporates discussion of biology, which is construed as a part of physics.

Chapter 5 contains an analysis of Kant's reflections regarding biology in the *Opus postumum*. I argue that these reflections must be read in the context of late eighteenth-century biological theories and metaphysical interpretations thereof. I further argue that Kant's views on biology as articulated in the *Opus*

postumum build upon his position developed in the *Kritik der Urteilkraft*. Kant reaffirms his critical position with respect to biology partly because of his encounter with particular biological theories and problematic metaphysical interpretations of the latter. Central to Kant's thought remains the idea that mechanism and teleology are regulative methodological maxims guiding scientific inquiry that do not have ontological implications.

In the *Opus postumum*, Kant reinterprets the theory of vital force espoused by the biologist Johann Friedrich Blumenbach. Blumenbach posited vital forces, constituting teleological agents in nature, in order to account for organic processes such as nutrition, reproduction and generation. Kant accepts Blumenbach's doctrine of vital force insofar as it gives expression to the idea that we must understand organisms and organic processes in teleological terms. However, he does not argue for the existence of vital forces in nature. This is to transgress the realms of proper science and to affirm the dogmatic metaphysical position of vitalism or hylozoism. Vital forces are reinterpreted as regulative posits, ascribed to organisms by analogy with human purposive action.

The *Opus postumum* further develops the idea that it is by conceptualizing certain objects (organisms) in teleological terms that we determine and delimit the object of biology. The distinction between inorganic and organic nature is not an ontological distinction. Rather, this distinction is an *a priori presupposition* of physics: a distinction preceding empirical investigation through which organic nature becomes a distinct object of scientific investigation. Once again, however, proper explanations in biology are always mechanical explanations. Biology is a part of physics and explanations of processes as (e.g.) nutrition, reproduction, etc., require the specification of physical and chemical causes of such processes, even if the nature of these causes is unknown to Kant and his contemporaries.

As in the third *Critique*, the *Opus postumum* contains a rejection of materialism and hylozoism. Materialism and hylozoism are dogmatic metaphysical theories denying respectively affirming the existence of purposiveness in nature. Kant's critique of materialism in the *Opus postumum* is shown to be related to his encounter with Samuel Thomas Sömmering's *Über das Organ der Seele* (1796), in which Sömmering provides a physiological investigation into the organ or seat of the soul. Kant criticized Sömmering for conflating metaphysical and physiological questions and for adopting a materialistic conception of the soul. Kant's critique of hylozoism in the *Opus postumum* is shown to be related to his encounter with Salomon Maimon's *Ueber die Weltseele* (1790), in which Maimon employed Blumenbach's theory of vital force to argue for the existence of a world-soul constituting the ground of

organic and inorganic bodies, of the life of animals and of understanding and reason in humans. According to Kant, this is a transgression from the field of biology to dogmatic metaphysics, i.e., hylozoism. The critique of materialism and hylozoism in the *Opus postumum* shows that this work cannot be interpreted, as is sometimes claimed, as a relapse into dogmatic positions.

Finally, I discuss Kant's reflections concerning natural history in the *Opus postumum* on the basis of his earlier views on natural history. I argue that Kant has a moderately positive view of natural history, i.e., the historical and developmental study of changes within nature and its (organic) objects. Natural history aims to provide causal explanations of present effects (e.g., specific traits of organisms) in terms of historical causes (objective grounds). Hence, Kant's views on proper scientific explanation led him to positively characterize natural history. However, Kant argued that certainty cannot be obtained in natural history. In addition, he denied that natural history can ever support the idea that organisms are generated from unorganized matter (which leads to materialism) and he was skeptical of ideas affirming the transformation of species. Finally, Kant thought that the results of natural history should be in conformity with viewing man as the ultimate and final end of nature. Kant thus placed severe restrictions on natural history. These restrictions can also be located in the *Opus postumum*.

In a study of Kant, one is always confronted with a vast research tradition to which one positions oneself and to which one is indebted. In conclusion, I would like to mention my main intellectual debts. In studying Kant's views on natural science and the methodology of natural science, I have greatly benefited from the work of Brigitte Falkenburg, Michael Friedman, Willem de Jong, Béatrice Longuenesse and Konstantin Pollok. In studying Kant's philosophy of biology, I have benefited from the work of Hannah Ginsborg, Timothy Lenoir, Peter McLaughlin, Marcel Quarfood, Robert Richards, Philip Sloan, John Zammito and Clark Zumbach. Finally, in studying Kant's *Opus postumum* I have benefited from the work of Erich Adickes, Dina Emundts, Eckart Förster and Michael Friedman.

